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(54) **ROTATIONAL BLUR-FREE IMAGE GENERATION**

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(52) **U.S. Cl.**

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(57) **ABSTRACT**

According to one implementation, an image generation system includes a rotor and a motor for spinning the rotor about an axis of rotation, and a display secured to the rotor. The display includes a display surface and a display aperture, a first privacy s screen situated at the display surface and having a convex curvature relative to light emitted from the display surface, and a second privacy screen situated between the first privacy screen and the display aperture and having a concave curvature relative to light emitted from the display surface. The first privacy screen and the second privacy screen are configured to substantially prevent rotational blur of an image displayed by the display surface while the display is spun by the motor and the rotor.

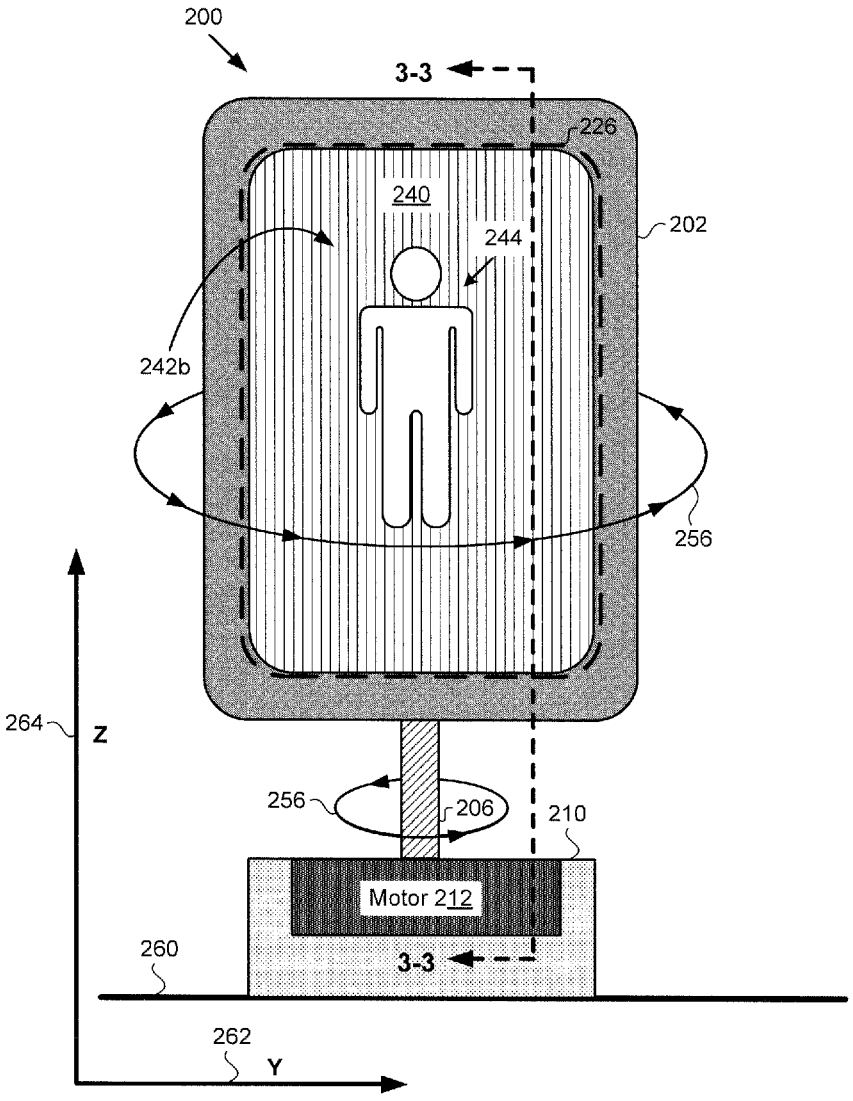


Fig. 1

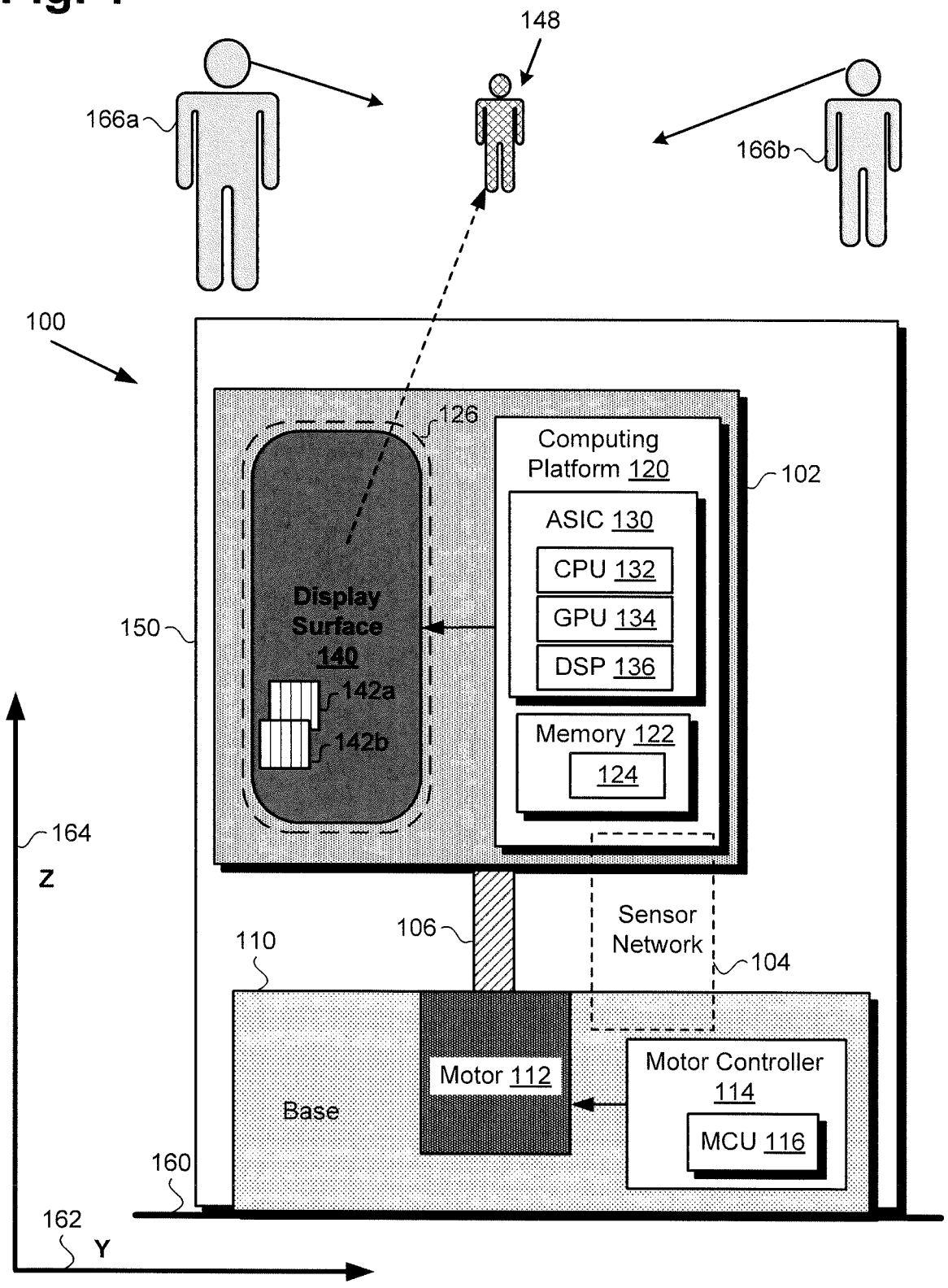

148
166a
166b
100
126
Computing Platform 120
102
ASIC 130
CPU 132
GPU 134
DSP 136
Memory 122
124
150
Display Surface 140
142a
142b
164
Z
106
110
Sensor Network
104
Motor 112
Motor Controller 114
MCU 116
Base
160
162
Y

Fig. 2

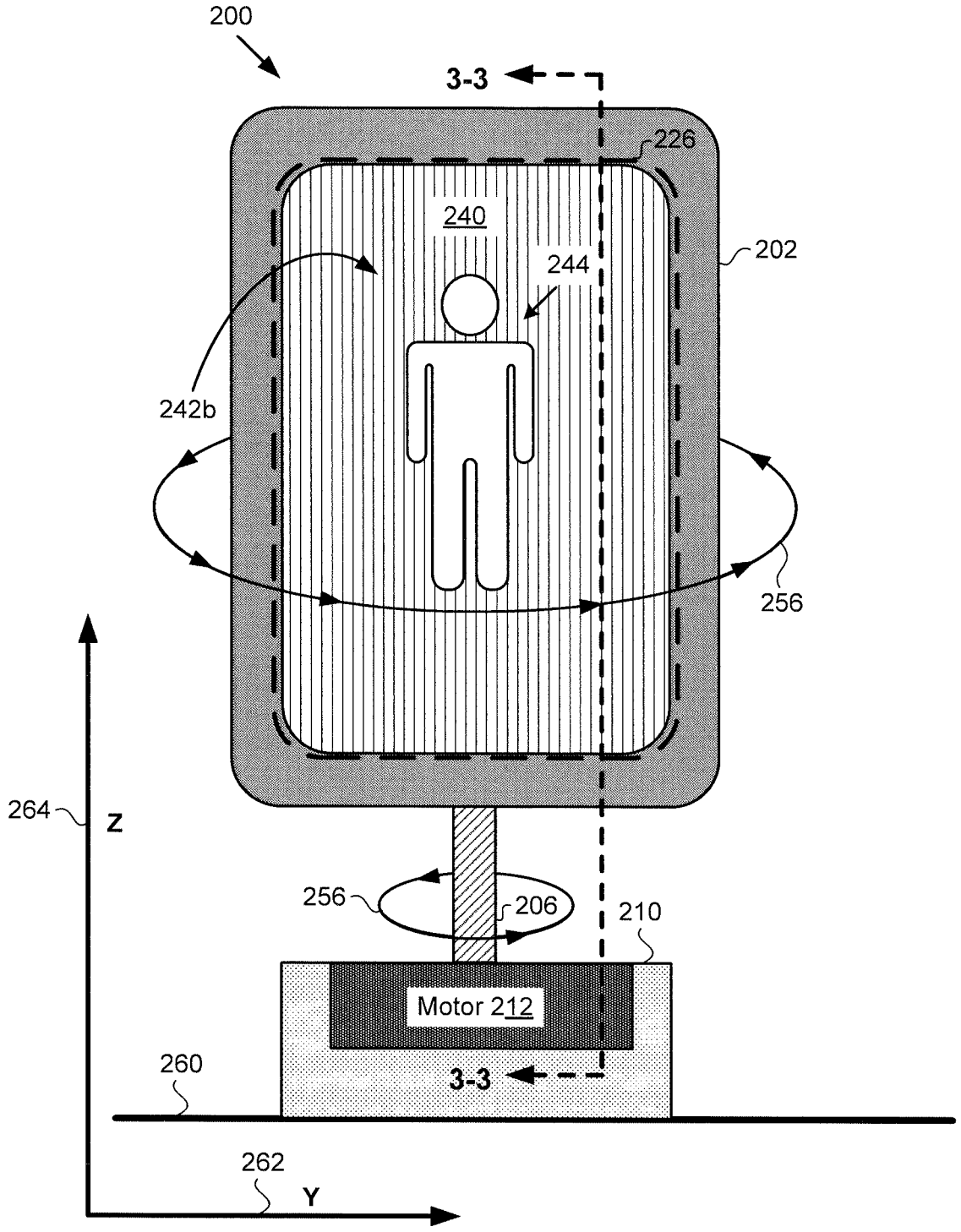

200
3-3
226
240
202
244
242b
256
264
Z
256
206
210
Motor 212
260
3-3
262
Y

Fig. 3

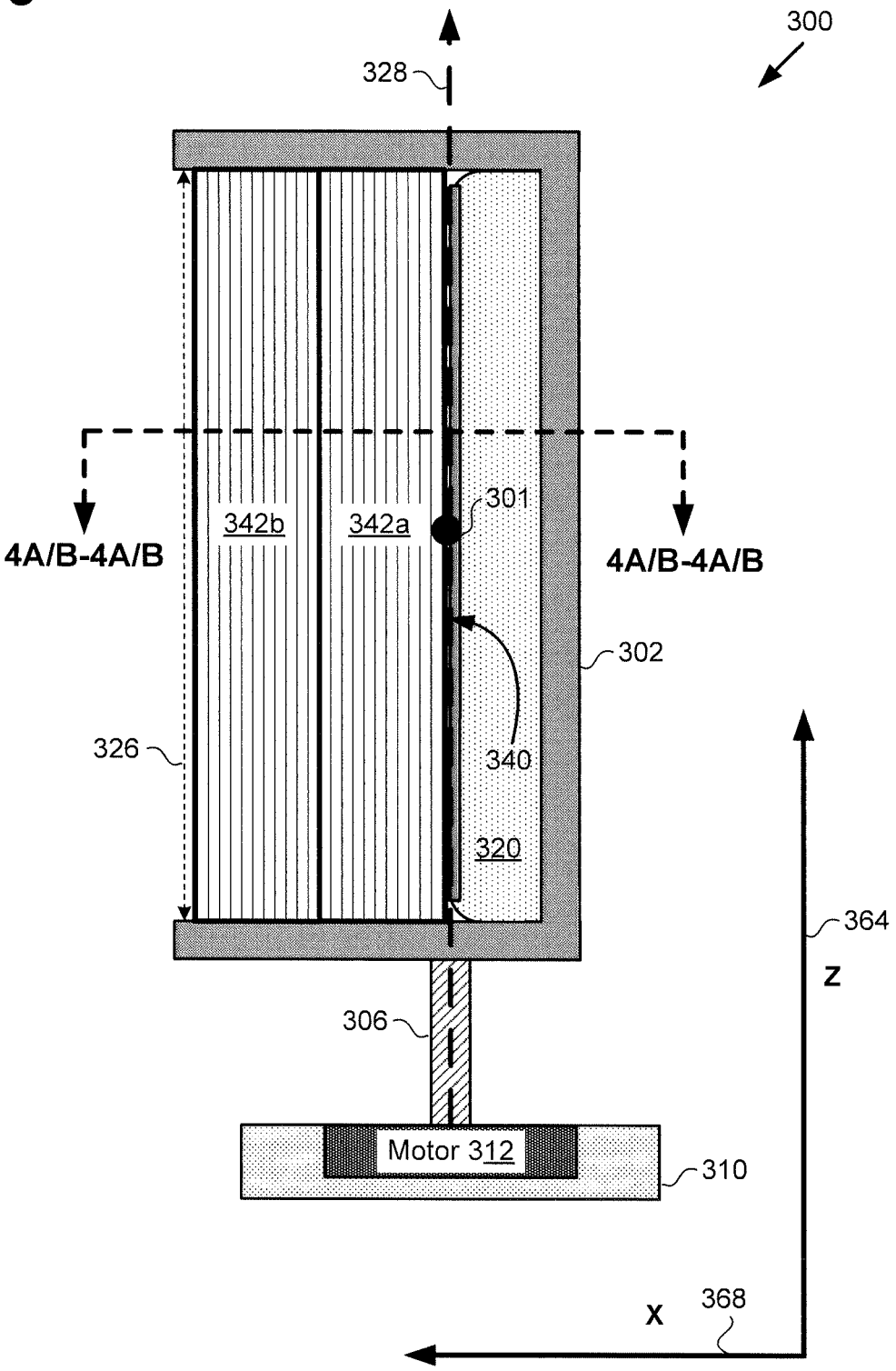

300
328
4A/B-4A/B
4A/B-4A/B
342b
342a
301
302
326
340
320
364
Z
306
Motor 312
310
X
368

Fig. 4A

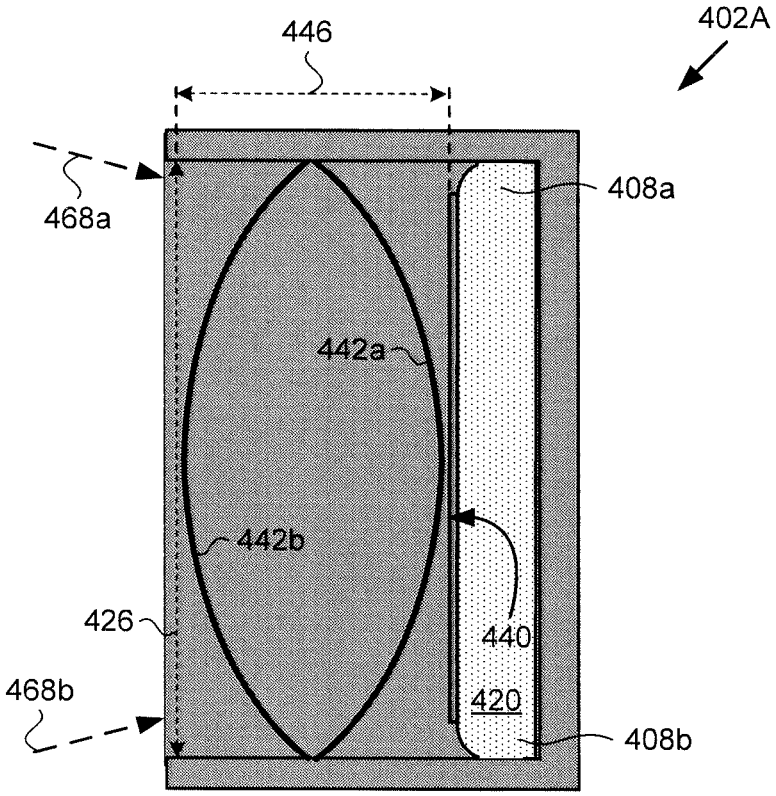

402A
446
468a
408a
442a
442b
426
440
420
468b
408b

Fig. 4B

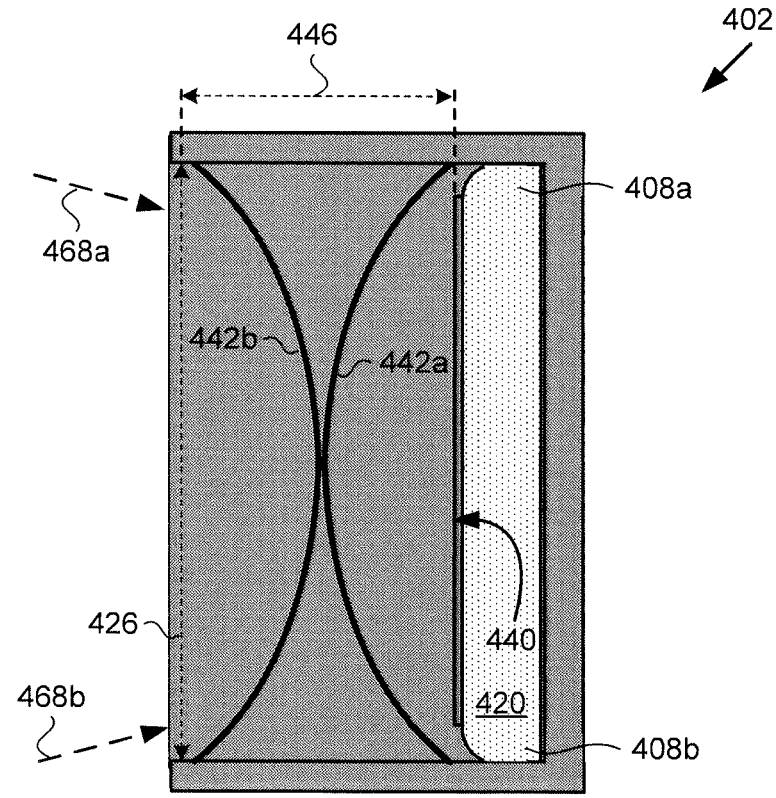

402B
446
468a
408a
442b
442a
426
440
420
468b
408b

Fig. 5

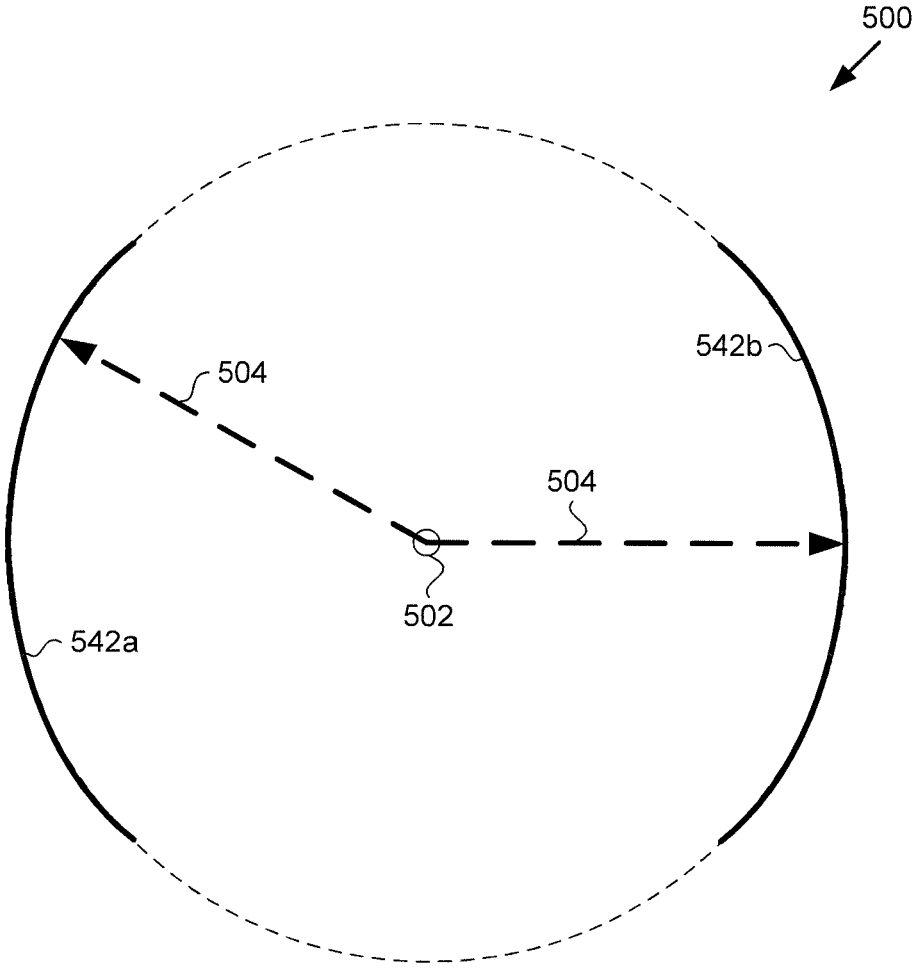
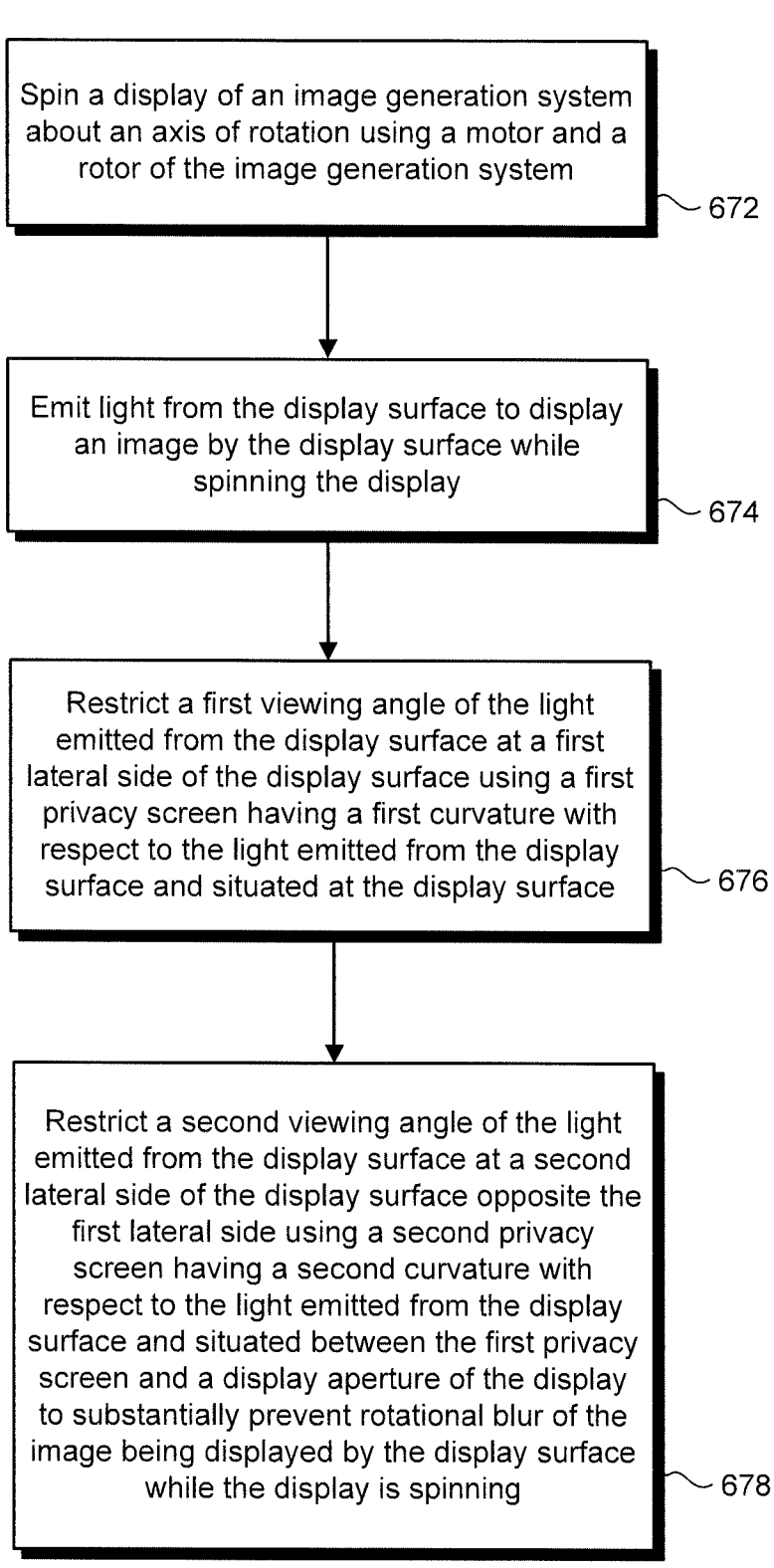


Fig. 6


670
Spin a display of an image generation system about an axis of rotation using a motor and a rotor of the image generation system
672
Emit light from the display surface to display an image by the display surface while spinning the display
674
Restrict a first viewing angle of the light emitted from the display surface at a first lateral side of the display surface using a first privacy screen having a first curvature with respect to the light emitted from the display surface and situated at the display surface
676
Restrict a second viewing angle of the light emitted from the display surface at a second lateral side of the display surface opposite the first lateral side using a second privacy screen having a second curvature with respect to the light emitted from the display surface and situated between the first privacy screen and a display aperture of the display to substantially prevent rotational blur of the image being displayed by the display surface while the display is spinning
678

ROTATIONAL BLUR-FREE IMAGE GENERATION

BACKGROUND

[0001] Increases in computing power have made possible the generation of richly featured virtual characters capable of simulating interactivity. The illusion of interactivity may be even greater when the virtual character appears to an observer to be independent of the image generation system producing it. For example, a spinning display may be used to generate an apparently three-dimensional (3D) image that appears to float in space. However, blurring of the floating image due to rotation of the display used to produce it may be readily detectable to the eye of a human observer, and may undesirably reduce the immersiveness of the interactive experience for the observer.

SUMMARY

[0002] There are provided systems and methods for performing rotational blur-free image generation, substantially as shown in and/or described in connection with at least one of the figures, and as set forth more completely in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. **1** shows a diagram of an exemplary image generation system including a spinning display, according to one implementation;

[0004] FIG. **2** shows a front view of an exemplary image generation system including a spinning display, according to one implementation;

[0005] FIG. **3** shows a cross-sectional side view of a portion of the exemplary image generation system shown in FIG. **2**;

[0006] FIG. **4**A shows a cross-sectional top view of one exemplary implementation of a display suitable for use in the image generation system shown in FIGS. **1**, **2**, and **3**;

[0007] FIG. **4**B shows a cross-sectional top view of another exemplary implementation of a display suitable for use in the image generation system shown in FIGS. **1**, **2**, and **3**;

[0008] FIG. **5** shows a diagram depicting a radius of curvature of each of first and second privacy screens suitable for use in the image generation systems of FIGS. **1**, **2**, and **3**; and

[0009] FIG. **6** shows a flowchart outlining an exemplary method for generating an image that is substantially free of rotational blur using a spinning display, according to one implementation.

DETAILED DESCRIPTION

[0010] The following description contains specific information pertaining to implementations in the present disclosure. One skilled in the art will recognize that the present disclosure may be implemented in a manner different from that specifically discussed herein. The drawings in the present application and their accompanying detailed description are directed to merely exemplary implementations. Unless noted otherwise, like or corresponding elements among the figures may be indicated by like or corresponding reference numerals. Moreover, the drawings and illustrations in the present application are generally not to scale, and are not intended to correspond to actual relative dimensions.

[0011] The present application discloses systems and methods for generating an image that is substantially free of rotational blur using a spinning display. FIG. **1** shows a diagram of exemplary image generation system **100**, according to one implementation. As shown in FIG. **1**, image generation system **100** includes display **102** configured to spin about an axis of rotation (axis of rotation not shown in FIG. **1**). In addition, exemplary image generation system **100** includes stationary base **110** coupled to display **102** by rotor **106**, and may further include masking shutter **150** surrounding at least display **102**.

[0012] As further shown in FIG. **1**, display **102** includes display surface **140**, display aperture **126** through which an image displayed by display surface **140** can be viewed, and computing platform **120** communicatively coupled to display surface **140** so as to control display surface **140**. Computing platform **120** includes application specific integrated circuit (ASIC) **130** including central processing unit (CPU) **132** implemented as a hardware processor, graphics processing unit (GPU) **134** also implemented as a hardware processor, and may further include digital signal processor (DSP) **136**. Computing platform **120** also includes system memory **122** implemented as a non-transitory storage device storing software code **124**.

[0013] Base **110** includes motor **112** for spinning rotor **106** and display **102**, as well as motor controller circuit **114** including motor control unit (MCU) **116**. Base **110** is situated on surface **160**, which may be a floor or any other substantially horizontal surface. In addition, FIG. **1** shows horizontal axis **162** substantially parallel to surface **160** and designated herein as the "Y" axis, and vertical axis **164** substantially perpendicular to surface **160** and designated herein as the "Z" axis. Also shown in FIG. **1** are first privacy screen **142***a* situated at display surface **140**, second privacy screen **142***b* situated between first privacy screen **142***a* and display aperture **126**, sensor network **104** bridging base **110** and display **102**, and image **148** displayed by display surface **140**, as well as observers **166***a* and **166***b* viewing image **148** through display aperture **126**, second privacy screen **142***b*, and first privacy screen **142***a*, from different perspectives.

[0014] By way of definition, as used in the present application, the terms "render" and "rendering" are defined to mean causing one or more images to appear on a display surface, such as display surface **140**. Thus, rendering an image may mean causing an entirely new image to appear on the display surface, or refreshing an image previously appearing on the display surface. Moreover, as used in the present application, the terms "central processing unit" or "CPU" and "graphics processing unit" or "GPU" have their customary meaning in the art. That is to say, a CPU includes an Arithmetic Logic Unit (ALU) for carrying out the arithmetic and logical operations of computing platform **120**, as well as a Control Unit (CU) for retrieving programs, such as software code **124**, from system memory **122**. A GPU is configured to reduce the processing overhead of the CPU by performing computationally intensive graphics processing tasks.

[0015] Sensor network **104** can include a base sensor unit integrated with base **110** and a rotating sensor unit integrated with display **102** and configured to rotate with display **102**. According to one implementation, the base sensor unit may include one or more of an infrared (IR) light-emitting diode (LED), a magnet, a visible light LED, and a glyph or other visible marker, to name a few examples. The rotating sensor

unit may include one or more of an IR receiver for sensing the IR LED, a Hall effect sensor for sensing the magnet, a photo diode for sensing the visible light LED, and one or more camera(s) for sensing the glyph or visible marker.

[0016] However, in another implementation, one or more of the IR LED, the magnet, the visible light LED, and the glyph or visible marker may be included in the rotating sensor unit, while one or more of the IR receiver, the Hall effect sensor, the photo diode, and the camera(s) may be included in the base sensor unit. It is noted that sensor unit **104** may be utilized to track the rotational position and/or spin rate of display **102**. Moreover, the combination of computing platform **120** of display **102**, sensor network **104**, and motor controller circuit **114** of base **110** enable the necessary time synchronization between the revolutions per second (rps) of motor **112** and rotor **106**, and the frame rate in frames per second (fps) at which display **102** renders images.

[0017] It is further noted that although FIG. **1** shows two observers **166***a* and **166***b*, that representation is provided merely for conceptual clarity. More generally, observers **166***a* and **166***b* may correspond to a single observer, or to more or many more than two observers who may be positioned so as to view image **148** from a variety of perspectives.

[0018] FIG. **2** shows a front view of exemplary image generation system **200**, according to one implementation. As shown in FIG. **2**, image generation system **200** includes base **210** and display **202**. Base **210** is shown to include motor **212** and to be situated on surface **260**, which may be a floor or any other substantially horizontal surface. In addition, according to the exemplary implementation shown in FIG. **2**, image generation system **200** includes rotor **206** securing display **202** to base **210**.

[0019] Display **202** includes display surface **240** and display aperture **226** through which two-dimensional (2D) graphic **244** rendered on display surface **240** can be viewed. FIG. **2** further shows second privacy screen **242***b*. Also shown in FIG. **2** are horizontal Y axis **262** substantially parallel to surface **260**, vertical Z axis **264** substantially perpendicular to surface **260**, and spin direction **256** of rotor **206** and display **202**.

[0020] Image generation system **200** corresponds in general to image generation system **100**, in FIG. **1**. As a result, image generation system **200** may share any of the characteristics attributed to image generation system **100** by the present disclosure, and vice versa. In addition, rotor **206** and base **210** including motor **212**, correspond respectively in general to rotor **106** and base **110** including motor **112**, in FIG. **1**. Thus, rotor **206**, base **210**, and motor **212**, may share any of the characteristics attributed to respective rotor **106**, base **110**, and motor **112**, by the present disclosure, and vice versa. That is to say, although not explicitly shown in FIG. **2**, base **210** includes features corresponding respectively to motor controller to circuit **114** and MCU **116**.

[0021] Moreover, display **202** including display aperture **226** and display surface **240** corresponds in general to display **102** including display aperture **126** and display surface **140**, in FIG. **1**. Thus, display **202**, display aperture **226**, and display surface **240** may share any of the characteristics attributed to respective display **102**, display aperture **126**, and display surface **140** by the present disclosure, and vice versa. That is to say, although not explicitly identified in FIG. **2**, display **202** includes a first privacy screen corresponding in general to first privacy screen **142***a*, in FIG. **1**, and situated between display surface **240** and second privacy screen **242***b*. Moreover, and although also not explicitly shown in FIG. **2**, display **202** may include features corresponding respectively to computing platform **120** including ASIC **130** having CPU **132**, GPU **134**, and DSP **136**, and further including system memory **122** storing software code **124**.

[0022] It is noted that second privacy screen **242***b*, in FIG. **2**, corresponds in general to second privacy screen **142***b*, in FIG. **1**. As a result, second privacy screen **242***b* may share any of the characteristics attributed to corresponding second privacy screen **142***b* by the present disclosure, and vice versa.

[0023] FIG. **3** shows a cross-sectional side view of exemplary image generation system **300** along perspective lines **3-3** in FIG. **2**, according to one implementation. As shown in FIG. **3**, image generation system **300** includes base **310** and display **302**. Base **310** is shown to include motor **312**. In addition, according to the exemplary implementation shown in FIG. **3**, image generation system **300** includes rotor **306** securing display **302** to base **310**.

[0024] Display **302** includes display surface **340** controlled by computing platform **320**, display aperture **326** through which an image displayed by display surface **340** can be viewed, first privacy screen **342***a* situated at display surface **340**, and second privacy screen **342***b* situated between first privacy screen **342***a* and display aperture **326**. Also shown in FIG. **3** are horizontal X axis **368** normal to display surface **340** and perpendicular to horizontal Y axis **162/262** in FIGS. **1** and **2**, vertical Z axis **364**, axis of rotation **328** of rotor **306** and display **302**, and center of mass **301** of display **302**.

[0025] Image generation system **300** corresponds in general to image generation system **100/200**, in FIGS. **1** and **2**. As a result, image generation system **300** may share any of the characteristics attributed to image generation system **100/200** by the present disclosure, and vice versa. In addition, rotor **306** and base **310** including motor **312**, correspond respectively in general to rotor **106/206** and base **110/210** including motor **112/212**, in FIGS. **1** and **2**. Thus, rotor **306**, base **310**, and motor **312**, may share any of the characteristics attributed to respective rotor **106/206**, base **110/210**, and motor **112/212**, by the present disclosure, and vice versa. That is to say, although not explicitly shown in FIG. **3**, base **310** includes features corresponding respectively to motor controller circuit **114** and MCU **116**.

[0026] Moreover, display **302** including display aperture **326** and display surface **340** corresponds in general to display **102/202** including display aperture **126/226** and display surface **140/240**, in FIGS. **1** and **2**. Thus, display **302**, display aperture **326**, to and display surface **340** may share any of the characteristics attributed to respective display **102/202**, display aperture **126/226**, and display surface **140/240** by the present disclosure, and vice versa. In addition, first privacy screen **342***a*, in FIG. **3**, corresponds in general to first privacy screen **142***a*, in FIG. **1**, while second privacy screen **342***b* corresponds in general to second privacy screen **142***b*/**242***b*, in FIGS. **1** and **2**. As a result, first privacy screen **342***a* may share any of the characteristics attributed to corresponding first privacy screen **142***a* by the present disclosure, and vice versa. Moreover, second privacy screen **342***b* may share any of the characteristics attributed

to corresponding second privacy screen **142***b*/**242***b* by the present disclosure, and vice versa.

[0027] Computing platform **320** of display **302** corresponds in general to computing platform **102**, in FIG. **1**. Consequently, and although also not explicitly shown in FIG. **3**, computing platform **320** of display **302** may include features corresponding respectively to ASIC **130** having CPU **132**, GPU **134**, and DSP **136**, and further including system memory **122** storing software code **124**.

[0028] As shown in FIG. **3**, display surface **140**/**240**/**340** of display **102**/**202**/**302** may be situated on axis of rotation **328** of rotor **106**/**206**/**306** and display **102**/**202**/**302**. For example, in some implementations, display surface **140**/**240**/**340** may be precisely aligned so as to be on axis of rotation **328** and so as to be centered on axis of rotation **328**. As further shown in FIG. **3**, center of mass **301** of display **102**/**202**/**302** may also be situated on axis of rotation **328** of rotor **106**/**206**/**306** and display **102**/**202**/**302**.

[0029] First privacy screen **142***a*/**342***a* and second privacy screen **142***b*/**242***b*/**342***b* may be implemented using any suitable materials configured to restrict the lateral angles from which display surface **140**/**240**/**340** may be viewed. It is noted that, as defined in the present application, the term "lateral viewing angle" refers to the angular deviation from X axis **368** in the plane defined by X axis **368** and Y axis **162**/**262** from which an image rendered by display surface **140**/**240**/**340** may be viewed by an observer of image generation system **100**/**200**/**300**, such as observers **166***a* and **166***b*.

[0030] By way of example, first privacy screen **142***a*/**342***a* and second privacy screen **142***b*/**242***b*/**342***b* may each be formed of a pliable polymer material, a thermoplastic, or a thermoset material. As specific but non-limiting examples, one or both of first privacy screen **142***a*/**342***a* and second privacy screen **142***b*/**242***b*/**342***b* may include one or more of polycarbonate, acrylic, and polyethylene.

[0031] In some implementations, first privacy screen **142***a*/**342***a* and second privacy screen **142***b*/**242***b*/**342***b* may be implemented using a commercially available privacy film typically used as a substantially flat sheet covering the surface of a computer monitor. Imposing a curvature on such a commercially available privacy film may further restrict the viewing angles it allows. For instance, a commercially available privacy film permitting a sixty degree viewing angle when implemented as a substantially flat screen may restrict the viewing angle to less than sixty degrees, or even significantly less than sixty degrees, when curved. Moreover, the additional viewing restriction imposed by curving such a material may increase as the curvature imposed on the material is increased.

[0032] Thus, first privacy screen **142***a*/**342***a* has a first curvature with respect to light emitted from display surface **140**/**240**/**340**, while second privacy screen **142***b*/**242***b*/**342***b* has a second curvature with respect to light emitted from display surface **140**/**240**/**340**. Moreover, including first privacy screen **142***a*/**342***a* having a first curvature with respect to light emitted from display surface **140**/**240**/**340** and second privacy screen **142***b*/**242***b*/**342***b* having a second curvature with respect to light emitted from display surface **140**/**240**/**340** as components of display **102**/**202**/**302** substantially prevents rotational blur of image **148** displayed by display surface **140**/**240**/**340** while display **10**^{2}/$_{2}$**02**/**302** is spinning.

[0033] FIG. **4**A shows a cross-sectional top view of display **402**A along perspective lines **4**A/B-**4**A/B in FIG. **3**, according to one exemplary implementation, while FIG. **4**B shows a cross-sectional top view of display **402**B along perspective lines **4**A/B-**4**A/B, according to another exemplary implementation. Each of displays **402**A and **402**B is shown to include display aperture **426** and display surface **440** controlled by computing platform **420**, as well as first privacy screen **442***a* having a first curvature and second privacy screen **442***b* having a second curvature.

[0034] FIGS. **4**A and **4**B also show viewing angle **468***a* at lateral side **408***a* of display surface **440**, viewing angle **468***b* at lateral side **408***b* of display surface **440**, and distance **446** between aperture **426** and display surface **440**. It is noted that either of viewing angles **468***a* and **468***b* may be referred to as a first viewing angle or a second viewing angle, while either of lateral sides **408***a* and **408***b* of display surface **440** may be referred to as a first lateral side or a second lateral side. It is further noted that distance **446** may be a distance of less than or approximately equal to twenty-five millimeters (25 mm), for example, such as a distance in a range from approximately 10 mm to approximately 25 mm.

[0035] Each of displays **402**A and **402**B can correspond in general to display **102**/**202**/**302** in FIGS. **1**, **2**, and **3**. As a result, display **102**/**202**/**302** may share any of the characteristics attributed to either of displays **402**A and **402**B by the present disclosure, and vice versa. In addition, display aperture **426**, display surface **440**, and second privacy screen **442***b* correspond respectively in general to display aperture **126**/**226**/**326**, display surface **140**/**240**/**340**, and second privacy screen **142***b*/**242***b*/**342***b*, in FIGS. **1**, **2**, and **3**. Furthermore, computing platform **420** and first privacy screen **442***a*, in FIGS. **4**A and **4**B, correspond respectively in general to computing platform **120**/**320** and first privacy screen **142***a*/**342***a*, in FIGS. **1** and **3**.

[0036] As shown in FIGS. **4**A and **4**B, the first and second curvatures of respective first privacy screen **142***a*/**342***a*/**442***a* and second privacy screen **142***b*/**242***b*/**342***b*/**442***b* may be substantially opposite. For example, as shown in FIG. **4**A, the first curvature of first privacy screen **142***a*/**342***a*/**442***a* may be convex with respect to light emitted from display surface **140**/**240**/**340**/**440**, while the second curvature of second privacy screen **142***b*/**242***b*/**342***b*/**442***b* may be concave with respect to light emitted from display surface **140**/**240**/**340**/**440**. Alternatively, and as shown by FIG. **4**B, the first curvature of first privacy screen **142***a*/**342***a*/**442***a* may be concave with respect to light emitted from display surface **140**/**240**/**340**/**440**, while the second curvature of second privacy screen **142***b*/**242***b*/**342***b* may be convex with respect to light emitted from display surface **140**/**240**/**340**.

[0037] FIG. **5** shows a diagram depicting a radius of curvature of each of first and second privacy screens **542***a* and **542***b* suitable for use in the image generation systems of FIGS. **1**, **2**, and **3**. As shown in FIG. **5**, circle **500** includes center of Is curvature **502**, and first and second privacy screens **542***a* and **542***b* depicted as circular arcs of circle **500**. Also shown in FIG. **5** is radius of curvature **504** of each of first and second privacy screens **542***a* and **542***b*.

[0038] It is noted that first privacy screen **542***a* corresponds in general to first privacy screen **142***a*/**342***a*/**442***a*, in FIGS. **1**, **3**, **4**A, and **4**B, and each of those features may share the characteristics attributed to any of those corresponding features by the present disclosure. In addition, second privacy screen **542***b*, in FIG. **5**, corresponds in general to

second privacy screen **142***b*/**242***b*/**342***b*/**442***b*, in FIGS. **1**, **2**, **3**, **4**A, and **4**B, and each of those features may share the characteristics attributed to any of those corresponding features by the present disclosure.

[0039] As known in the art, "curvature" is the inverse of radius of curvature. In other words, the larger the radius of curvature of a circular arc, the smaller its curvature. As s shown by FIG. **5**, in one implementation, first privacy screen **142***a*/**342***a*/**442***a*/**542***a* and second privacy screen **142***b*/**242***b*/**342***b*/**442***b*/**542***b* may have substantially the same radius of curvature **504**. Thus, in that implementation, the magnitude of first curvature of first privacy screen **142***a*/**342***a*/**442***a*/**542***a* substantially equals the magnitude of second curvature of second privacy screen **142***b*/**242***b*/**342***b*/**442***b*/**542***b*. Moreover, and as shown by FIGS. **4**A and **4**B, the first curvature of first privacy screen **142***a*/**342***a*/**442***a*/**542***a* may be substantially opposite the second curvature of second privacy screen **142***b*/**242***b*/**342***b*/**442***b*/**542***b*. That is to say, in implementations in which first privacy screen **142***a*/**342***a*/**442***a*/**542***a* is convex with respect to light emitted from display surface **140**/**240**/**340**/**440**, second privacy screen **142***b*/**242***b*/**342***b*/**442***b*/**542***b* may be concave with respect to light emitted from display surface **140**/**240**/**340**/**440**, and vice versa.

[0040] Referring to FIGS. **1**, **2**, **3**, **4**A, and **4**B in combination, display surface **140**/**240**/**340**/**440** may be controlled by CPU **132** and/or GPU **134** of ASIC **130**, while rotor **106**/**206**/**306** coupled to display **102**/**202**/**302**/**402**A/**402**B is controlled by CPU **132** of ASIC **130**. CPU **132** of ASIC **130** is configured to execute software code **124** to render 2D graphic **244** on display surface **140**/**240**/**340**/**440**.

[0041] CPU **132** is further configured to execute software code **124** to utilize motor **112**/**212**/**312** to spin rotor **106**/**206**/**306** and display **102**/**202**/**302**/**402**A/**402**B about axis of rotation **328** at a predetermined spin rate to generate image **148** corresponding to 2D graphic **244**. As a result of the image generation performed by spinning of display **102**/**202**/**302**/**402**A,**402**B, image **148** may appear to be floating in space, and may appear to be a three-dimensional (3D) floating image corresponding to 2D graphic **244** rendered on display surface **140**/**240**/**340**/**440**.

[0042] In some implementations, display surface **140**/**240**/**340**/**440** may be a liquid crystal display (LCD) screen, or an organic light-emitting diode (OLED) display screen, for example. Moreover, in some implementations, display surface **140**/**240**/**340**/**440** may be part of a mobile communication device serving as computing platform **120**/**320**/**420**, the mobile communication device being integrated with display **102**/**202**/**302**/**402**A/**402**B, and being configured to spin with rotor **106**/**206**/**306** and display **102**/**202**/**302**/**402**A/**402**B at the predetermined spin rate. For example, display surface **140**/**240**/**340**/**440** may be part of a smartphone or a tablet computer providing computing platform **120**/**320**/**420**.

[0043] It is noted that CPU **132** may execute software code **124** to control motor **112**/**212**/**312** in order to spin rotor **106**/**206**/**306** and display **102**/**202**/**302**/**402**A/**402**B about axis of rotation **328** at a varying spin rate, or at a substantially constant predetermined spin rate. It is also noted that spin direction **256** may be in either a counter clockwise direction with respect to the plane of horizontal X axis **368** and Y axis **162**/**262**, as shown in FIG. **2**, or in a clockwise direction with respect to that plane.

[0044] In some implementations, CPU **132** may execute software code **124** to use GPU **134** to change 2D graphic **244** as rotor **106**/**206**/**306** and display **102**/**202**/**302**/**402**A/**402**B spin, so as to generate multiple perspectives of image **148** that are appropriate respectively to the locations of each of observers **166***a* and **166***b*. For example, observer **166***a* located so as to face a front side of image **148** and stationary at that location might consistently view image **148** from a frontal perspective. By contrast, observer **166***b* located so as to face a backside of image **148**, i.e., 180° apart from the perspective of observer **166***a*, and stationary at that location might consistently view image **148** as if from the rear.

[0045] In some use cases, it may be advantageous or desirable to enhance the illusion that image **148** is floating in space independently of display **102**/**202**/**302**/**402**A/**402**B. When implemented for those use cases, display **102**/**202**/**302**/**402**A/**402**B may be surrounded by masking shutter **150**. Masking shutter **150** may be implemented as a liquid-crystal shutter, such as a polymer-dispersed liquid-crystal (PDLC), or "smart glass" shutter, for example. Alternatively, masking shutter **150** may be implemented using any suitable electrochromic, photochromic, or thermochromic material. For example, in one implementation, masking shutter **150** may be implemented as a suspended-particle device (SPD), while in another implementation, masking shutter **150** may be implemented using a material that changes transparency in response to exposure to ultraviolet (UV) light.

[0046] The functionality of image generation system **100**/**200**/**300** including display **102**/**202**/**302**/**402**A/**402**B configured to spin will be further described by reference to FIG. **6**. FIG. **6** shows flowchart **670** outlining an exemplary method for generating an image that is substantially free of rotational blur using a spinning display, according to one implementation. With respect to the method described by FIG. **6**, it is noted that certain details and features have been left out of flowchart **670** in order not to obscure the discussion of the inventive features in the present application.

[0047] Referring to FIG. **6** in combination with FIGS. **1**, **2**, **3**, **4**A, and **4**B, flowchart **670** begins with spinning display **102**/**202**/**302**/**402**A/**402**B about axis of rotation **328** using motor **112**/**212**/**312** and rotor **106**/**206**/**306** (action **672**). As noted above, spinning of display **102**/**202**/**302**/**402**A/**402**B about axis of rotation **328** may be performed using motor **112**/**212**/**312** and rotor **106**/**206**/**306** under the control of software code **124**, executed by CPU **132** of ASIC **130**, and using a predetermined spin rate or a variable spin rate.

[0048] Flowchart **670** continues with emitting light from display surface **140**/**240**/**340**/**440** to display image **148** by display surface **140**/**240**/**340**/**440** while spinning display **102**/**202**/**302**/**402**A/**402**B (action **674**). Emission of light from display surface **140**/**240**/**340**/**440** to display image **148** may be performed by software code **124**, executed by CPU **132** of ASIC **130**, and may include use of GPU **134**. As noted above, as a result of the image generation performed by spinning of display **102**/**202**/**302**/**402**A/**402**B, image **148** may appear to be a 3D image corresponding to 2D graphic **244** rendered on display surface **140**/**240**/**340**/**440**. Furthermore, image **148** may appear to be a 3D image floating in space.

[0049] Referring to FIG. **5** in combination with FIGS. **1**, **2**, **3**, **4**A, and **4**B, flowchart **670** continues with restricting first viewing angle **468***a*/**468***b* of the light emitted from display surface **140**/**240**/**340**/**440** at first lateral side **408***a*/**408***b* of display surface **140**/**240**/**340**/**440** using first privacy screen **142***a*/**342***a*/**442***a*/**542***a* having a first curvature with respect to the light emitted from display surface **140**/**240**/

340/440 and situated at display surface 140/240/340/440 (action 676). As shown by FIG. 4A, in some implementations, first privacy screen 142*a*/342*a*/442*a*/542*a* may be convex with respect to light emitted from display surface 140/240/340/440. As further shown by FIG. 4B, in other implementations, first privacy screen 142*a*/342*a*/442*a*/542*a* may be concave with respect to light emitted from display surface 140/240/340/440.

[0050] Flowchart 670 can conclude with restricting second viewing angle 468*b*/468*a* of the light emitted from display surface 140/240/340/440 at second lateral side 408*b*/408*a* of display surface 140/240/340/440 opposite first lateral side 408*a*/408*b* using second privacy screen 142*b*/242*b*/342*b*/442*b*/542*b* having a second curvature with respect to the light emitted from display surface 140/240/340/440 and situated between first privacy screen 142*a*/342*a*/442*a*/542*a* and display aperture 126/226/326/426 to substantially prevent rotational blur of image 148 being displayed by display surface 140/240/340/440 while display 102/202/302/402A/402B is spinning (action 678).

[0051] As shown by FIG. 4A, in implementations in which first privacy screen 142*a*/342*a*/442*a*/542*a* is convex with respect to light emitted from display surface 140/240/340/440, second privacy screen 142*b*/242*b*/342*b*/442*b*/542*b* may be concave with respect to light emitted from display surface 140/240/340/440. As further shown by FIG. 4B, in implementations in which first privacy screen 142*a*/342*a*/442*a*/542*a* is concave with respect to light emitted from display surface 140/240/340/440, second privacy screen 142*b*/242*b*/342*b*/442*b*/542*b* may be convex with respect to light emitted from display surface 140/240/340/440.

[0052] It is noted that depending on its curvature, i.e., convex or concave, and the direction of rotation of rotor 106/206/306 and display 102/202/302/402A/402B, first privacy screen 142*a*/342*a*/442*a*/542*a* can substantially prevent rotational blur of image 148 being displayed by display surface 140/240/340/440 at one of first lateral side 408*a*/408*b* and second lateral side 408*b*/408*a* while display 102/202/302/402A/402B is spinning. When second privacy screen 142*b*/242*b*/342*b*/442*b*/542*b* has the opposite curvature, i.e., concave or convex, second privacy screen 142*b*/242*b*/342*b*/442*b*/542*b* can substantially prevent rotational blur of image 148 being displayed by display surface 140/240/340/440 at the opposite of first lateral side 408*a*/408*b* and second lateral side 408*b*/408*a* while display 102/202/302/402A/402B is spinning.

[0053] Thus, use of first privacy screen 142*a*/342*a*/442*a*/542*a* and second privacy screen 142*b*/242*b*/342*b*/442*b*/542*b*, in combination, can substantially prevent rotational blur of image 148 while display 102/202/302/402A/402B is spinning. That is to say, first privacy screen 142*a*/342*a*/442*a*/542*a* and second privacy screen 142*b*/242*b*/342*b*/442*b*/542*b*, when implemented together, can advantageously render rotational blur of image 148 generated by spinning display 102/202/302/402A/402B substantially imperceptible to observers 166*a* and 166*b*.

[0054] As described above, the present application discloses systems and methods for generating an image that is substantially free of rotational blur using a spinning display. By rendering a 2D graphic on a display surface of a display and spinning the display using a motor and a rotor, the systems and methods disclosed by the present application enable the generation of an apparently 3D floating image corresponding to to the 2D graphic. Moreover, by utilizing first and second oppositely curved privacy screens to restrict viewing angles at opposite lateral sides of the display surface, the present solution advantageously enables generation of the 3D image having no perceptible rotational blur.

[0055] From the above description it is manifest that various techniques can be used for implementing the concepts described in the present application without departing from the scope of those concepts. Moreover, while the concepts have been described with specific reference to certain implementations, a person of ordinary skill in the art would recognize that changes can be made in form and detail without departing from the scope of those concepts. As such, the described implementations are to be considered in all respects as illustrative and not restrictive. It should also be understood that the present application is not limited to the particular implementations described herein, but many rearrangements, modifications, and substitutions are possible without departing from the scope of the present disclosure.

What is claimed is:

1. An image generation system comprising:
- a base including a rotor and a motor for spinning the rotor about an axis of rotation;
- a display secured to the rotor, wherein the display includes a display surface and a display aperture;
- a first privacy screen situated at the display surface, the first privacy screen having a convex curvature relative to light emitted from the display surface;
- a second privacy screen situated between the first privacy screen and the display aperture, the second privacy screen having a concave curvature relative to light emitted from the display surface;
- wherein the first privacy screen and the second privacy screen are configured to substantially prevent rotational blur of an image displayed by the display surface while the display is spun by the motor and the rotor.

2. The image generation system of claim 1, wherein the display surface is on the axis of rotation.

3. The image generation system of claim 1, wherein a radius of curvature of the first privacy screen and a radius of curvature of the second privacy screen are substantially the same.

4. The image generation system of claim 1, wherein the first privacy screen and the second privacy screen comprise at least one of polycarbonate, acrylic, and polyethylene.

5. The image generation system of claim 1, wherein the image displayed by the display surface is rendered as a two-dimensional (2D) graphic on the display surface, and wherein spinning the display by the motor and the rotor causes the rendered 2D graphic to appear as a three-dimensional (3D) floating image.

6. The image generation system of claim 1, wherein the display surface is part of a mobile communication device configured to spin with the display.

7. An image generation system comprising:
- a base including a rotor and a motor for spinning the rotor about an axis of rotation;
- a display secured to the rotor, wherein the display includes a display surface and a display aperture;
- a first privacy screen situated at the display surface, the first privacy screen having a concave curvature relative to light emitted from the display surface;
- a second privacy screen situated between the first privacy screen and the display aperture, the second privacy

screen having a convex curvature relative to light emitted from the display surface;

wherein the first privacy screen and the second privacy screen are configured to substantially prevent rotational blur of an image displayed by the display surface while the display is spun by the motor and the rotor.

8. The image generation system of claim **7**, wherein the display surface is on the axis of rotation.

9. The image generation system of claim **7**, wherein a radius of curvature of the first privacy screen and a radius of curvature of the second privacy screen are substantially the same.

10. The image generation system of claim **7**, wherein the first privacy screen and the second privacy screen comprise at least one of polycarbonate, acrylic, and polyethylene.

11. The image generation system of claim **7**, wherein the image displayed by the display surface is rendered as a two-dimensional (2D) graphic on the display surface, and wherein spinning the display by the motor and the rotor causes the rendered 2D graphic to appear as a three-dimensional (3D) floating image.

12. The image generation system of claim **7**, wherein the display surface is part of a mobile communication device configured to spin with the display.

13. A method for use by an image generation system having a base including a rotor and a motor for spinning the rotor about an axis of rotation, a display secured to the rotor, wherein the display includes a display surface and a display aperture, a first privacy screen situated at the display surface, the first privacy screen having a first curvature relative to light emitted from the display surface, and a second privacy screen situated between the first privacy screen and the display aperture, the second privacy screen having a second curvature relative to light emitted from the display surface, the method comprising:

spinning the display, using the motor and the rotor, about the axis of rotation;

emitting light from the display surface to display an image while spinning the display;

restricting a first viewing angle of the light emitted from the display surface at a first lateral side of the display surface using the first privacy screen having the first curvature; and

restricting a second viewing angle of the light emitted from the display surface at a second lateral side of the display surface opposite the first lateral side using the second privacy screen having the second curvature to substantially prevent rotational blur of the image being displayed by the display surface while the display is spinning.

14. The method of claim **13**, wherein the first curvature is convex relative to light emitted from the display surface and wherein the second curvature is concave relative to light emitted from the display surface.

15. The method of claim **13**, wherein the first curvature is concave relative to light emitted from the display surface and wherein the second curvature is convex relative to light emitted from the display surface.

16. The method of claim **13**, wherein the display surface is on the axis of rotation.

17. The method of claim **13**, wherein a radius of curvature of the first privacy screen and a radius of curvature of the second privacy screen are substantially the same.

18. The method of claim **13**, wherein the first privacy screen and the second privacy screen comprise at least one of polycarbonate, acrylic, and polyethylene.

19. The method of claim **13**, wherein the image displayed by the display surface is rendered as a two-dimensional (2D) graphic on the display surface, and wherein spinning the display by the motor and the rotor causes the rendered 2D graphic to appear as a three-dimensional (3D) floating image.

20. The method of claim **13**, wherein the display surface is part of a mobile communication device configured to spin with the display.

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